§6. Examination of Up/down Symmetry of Highly Ionized Tungsten Ions in Core Region of LHD Plasmas

Morita, S., Huang, X.L., Oishi, T., Goto, M., Zhang, H.M.

Recently, up/down and inboard/outboard asymmetric profiles of high-Z impurities in plasma core region have been extensively studied in many tokamaks [1,2], while the electron density and temperature are thought to be constant along a magnetic surface. An anomalous radial transport which can influence the parallel force balance, centrifugal effect, toroidal rotation and so on are considered as the origin. The up/down has been also examined in LHD using two space-resolved EUV spectrometers.

An EUV_Short2 spectrometer working in 10-100Å measures vertical impurity line profiles from upper half ($0 \leq Z \leq 50$cm) of LHD elliptical plasmas at horizontally elongated plasma cross section, as shown in Fig.1(a). On the contrary, an EUV_Long2 spectrometer working in 30-650 Å can measure any vertical position of LHD plasmas, as shown in Fig.1(b) by changing the spectrometer optical axis vertically. In order to compare the vertical impurity line emission profile between upper and lower half plasma ranges, then, the EUV_Long2 spectrometer is set to observe the lower half profile ($-50 \leq Z \leq 0$cm).

Typical results are shown in Fig.2 for WXXV at 32.7-33.1 Å and WXXVIII at 47.8-48.3 Å. The up/down profiles are normalized at Z=0 to produce the full vertical profile. Since those two ions (W^{24+} and W^{27+}) have relatively large ionization energy of 734 and 881eV, respectively, the emission is located in the core region of LHD plasmas. Both the profiles seem to show a symmetric distribution between up and down positions. An edge line emission of CVI (33.7Å) localizing near Last Closed Flux Surface is also plotted in the figure. The profile shows the emission intensity is large at the lower half of the plasma affected by an effect of the ergodic layer consisting of stochastic magnetic fields. In LHD all impurity line emissions localizing in the ergodic layer show a poloidally non-uniform intensity distribution such as CVI in Fig.2. Therefore, the radial profile of impurity emissions is entirely different between the core region and ergodic layer.

Figure 3 shows temporal behavior of the line intensity. A tungsten pellet injected at 4.8s and the intensity is normalized at a relatively stable emission phase after the pellet injection. The profile shown in Fig.2 is plotted at the maximum intensity just after the pellet injection. The intensity at up and down positions is denoted by open and solid symbols in Fig.3, respectively. The intensity from highly ionized tungsten ions shows a very similar temporal behavior between up and down positions. Therefore, we can conclude the tungsten emission has a symmetric profile at up and down positions, at least in discharges with tungsten pellet. The analysis will be also carried out to intrinsic iron impurity because the data for analysis can be extended to wider discharge conditions.

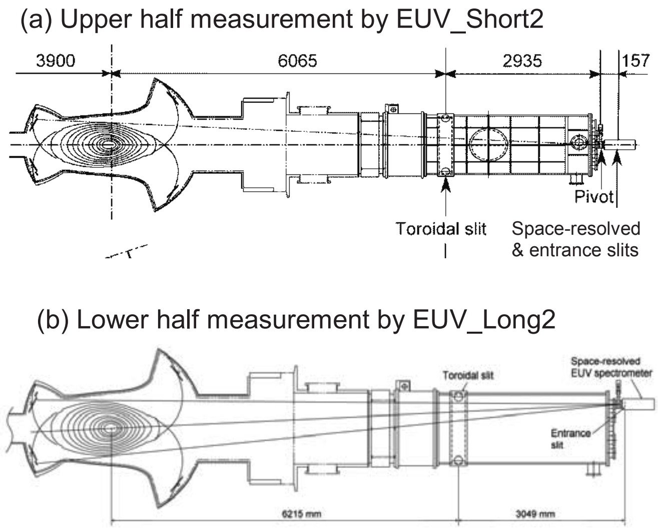

Fig.1 (a) EUV_Short2 spectrometer for upper half profile measurement (b) EUV_Long2 spectrometer for lower half profile measurement.

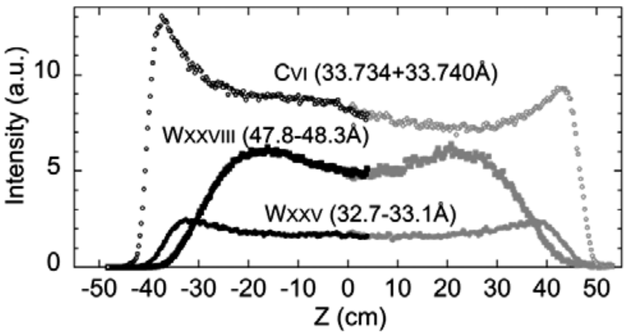

Fig.2 Full vertical distributions of CVI, WXXV and WXXVIII combined with upper- and lower-half profiles obtained by EUV_Short2 and EUV_Long2, respectively.

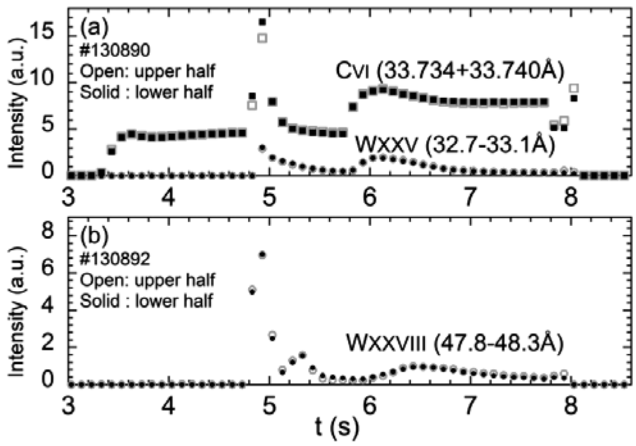

Fig.3 Temporal intensity behaviors of CVI, WXXV and WXXVIII. A tungsten pellet (tungsten wire inserted into cylindrical graphite pellet) is injected at t=4.8s.

1) Angioni, C. et al.: PPCF 56 (2014) 124001.
2) Reinke M.L. et al.: NF 53 (2013) 043006.